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ABSTRACT

This teacher's guide contains information, lesson plans, and diverse student learning activities focusing on space flight. The guide is divided into seven sections: (1) "Drawing Activities" (Future Flight; Space Fun; Mission: Draw); (2) "Geography" (Space Places); (3) "History" (Space and Time); (4) "Information" (Space Transportation System; Educator's History of Space Flight); (5) "Language Arts" (Space Scramble; Shuttle Jumble); (6) "Lesson Plans" (Minds in Motion; Where Were You When...?); and (7) "Math" (Space Math; Message from the Moon). (BT)

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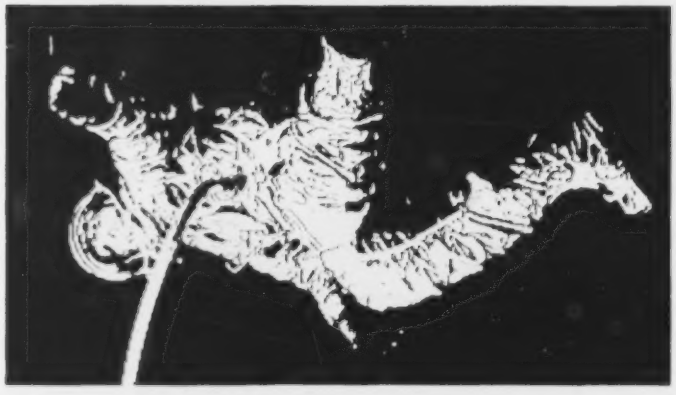
Teacher Resources

Space Flight



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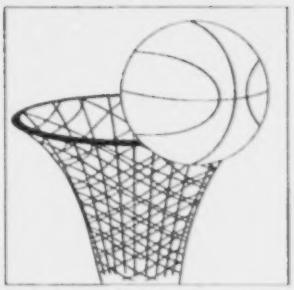
FUTURE FLIGHT

The United States and many other nations are working together to build ar International Space Station, a place for people to live and work in space. The current Space Shuttle is used to take parts of the space station into orbit so that it can be put together. When the Space Station is finished, two new space craft will be needed: a small one designed to carry only people back and forth to the station, and a bigger one (like the Space Shuttle, only newer) to take supplies and large pieces of equipment up to the station. Help the designers of Space Station Alpha by drawing a picture of one of these spacecraft. Explain its features by labeling your drawing.

FUN IN SPACE



You have probably seen videotapes of astronauts "floating" in space. Astronauts traveling aboard the Space Shuttle experience microgravity, or the sensation of weightlessness. Microgravity makes everyday actions such as eating, drinking, sleeping and running difficult. Imagine what it would be like to play your favorite sport or do your favorite hobby in space and draw a picture of it below. Remember that microgravity affects everything that is not fastened to the shuttle (including balls, decks of cards and bottles of paint)! Write a sentence or two below your drawing to describe how you would accomplish your favorite activity in space.

MISSION: DRAW

Since the earliest space flights, each mission has been designated by a patch. Astronauts wear these patches on their shirts and flight suits. Mission patches are designed to reflect the significance of each particular mission. The Apollo 8 mission, for example, was the first to orbit the moon, so its patch uses a number eight to represent the spacecraft's orbit around the earth and the moon. Imagine that a special mission to the moon or a planet is about to occur and that you have been chosen to design its patch. Draw your design below and write a few sentences about the mission and how your patch represents it.

Apollo 8 mission patch

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SPACE PLACES

Space exploration involves the whole world. Write the number of each landmark in the correct circle on the map. You may need to use a globe or an atlas.

1. China—where gunpowder was invented and rockets were first used
2. England—where Sir Isaac Newton studied gravity
3. France—where Jules Verne wrote *From the Earth to the Moon*
4. Germany—where the first practical rocket (the V-2) was developed
5. Italy—where Galileo observed the moon
6. Kazakhstan—where Soviets launched the first satellite (*Sputnik*) and manned rocket (*Vostok I*)
7. Russia—where Konstantin Tsiolkovsky developed ideas for modern rockets
8. Pacific Ocean southwest of Hawaii—where Apollo 11 splashed down
9. Auburn, Massachusetts—where Robert Goddard built his first rocket
10. Kennedy Space Center, Florida—where NASA launched the Apollo rockets
11. Johnson Space Center, Houston, Texas—where NASA trains astronauts and guides manned space missions
12. Huntsville, Alabama—where NASA built the Saturn moon rocket

SPACE AND TIME

The following sentences describe important events in the history of space flight and exploration. Put the sentences in order by date by numbering them from one to ten (one would be the first event that occured; ten would be the most recent one). When you are done, read the sentences, beginning with number one, and learn more about what it took to get into space.

____ 1687: Isaac Newton developed the three laws of motion that explain rocket launching and orbit.

____ 1981: NASA launched *Columbia*, the first in a series of space shuttles.

____ 1926: Robert Goddard, an American, built and fired the first liquid-fuel rocket.

____ 1232: The first recorded use of rockets occurred in China.

____ 1997: The Mars Rover landed on and explored the surface of Mars.

____ 1957: The Soviet Union launched the first successful space craft, *Sputnik*.

____ 1903: Konstantin Tsiolkovsky drew plans for rockets that he believed would lead to space travel.

____ 1986: The Soviet Union launched Space Station Mir.

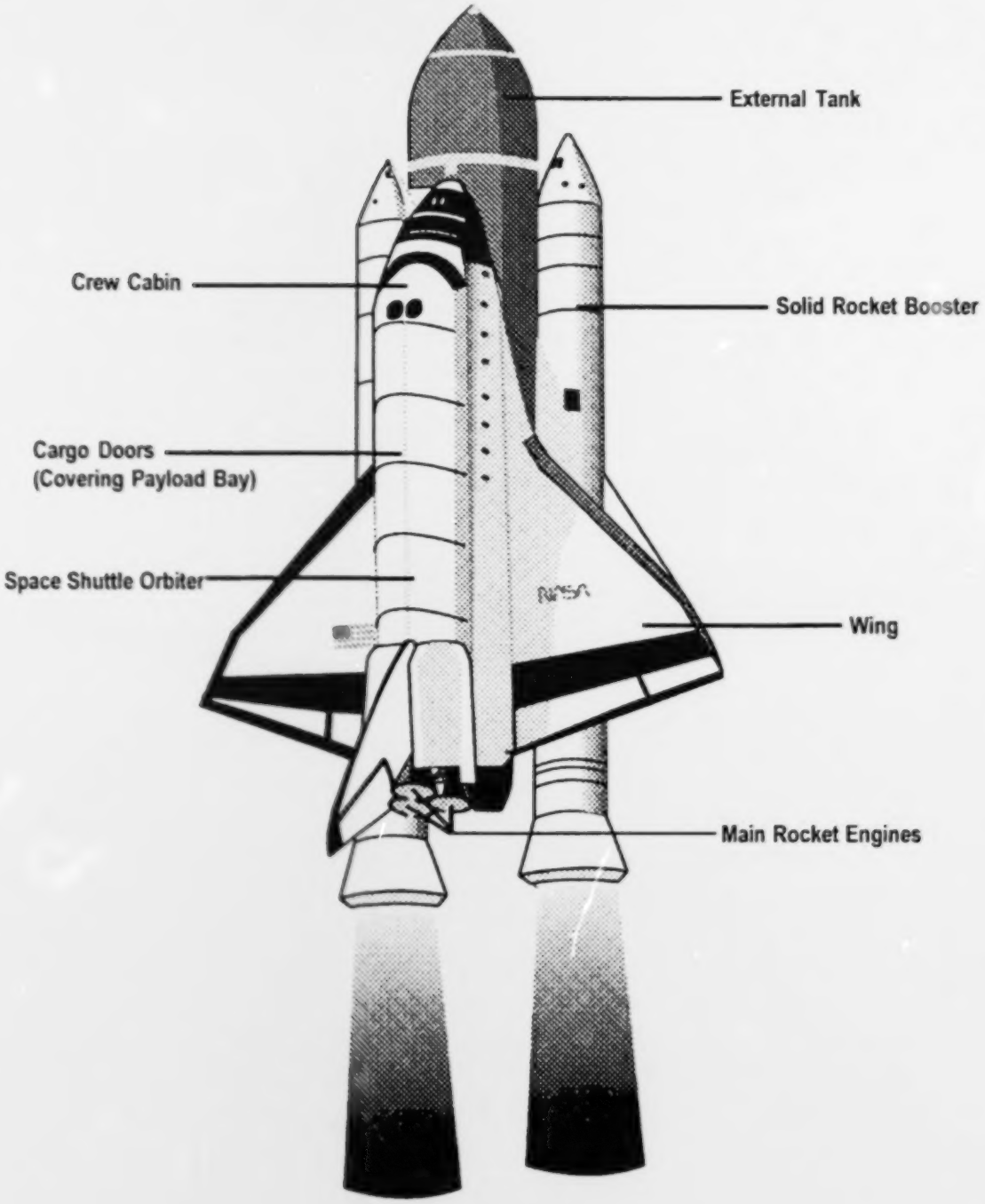
____ 1969: Neil Armstrong took the first step on the moon.

____ 960: Gunpowder, used in the first rockets, was invented in China.

____ 1961: Soviet Cosmonaut Yuri Gagarin became the first human in space.

Space Transportation System

(Space Shuttle Orbiter, Tank, and Boosters)



A BRIEF HISTORY OF FLIGHT

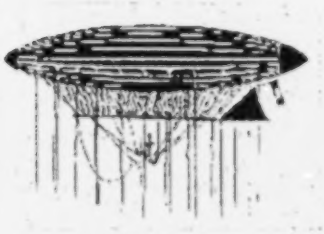
BACKGROUND INFORMATION FOR EDUCATORS

The idea of flight has fascinated people since the dawn of history. From the Greek legend of Daedalus and Icarus to space station Mir, people have been discussing, analyzing, attempting and achieving flight. Though technology has advanced dramatically, the dream of progress still remains.

While perhaps more famous for his artworks, Leonardo da Vinci was the first to make a scientific study of flight mechanics. In the late 15th century, he made sketches of a flying machine called an ornithopter, which had wings that would flap when the "pilot" moved his arms and legs. The basic principle was to enable a man to fly like a bird. Da Vinci never actually built an ornithopter, but if he had, it would not have worked: humans simply do not have the strength to lift their weight by flapping a pair of strapped-on wings.

Montgolfier balloon

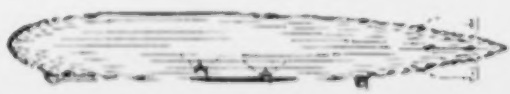
The first successful flying machines were hot-air balloons built by the French Montgolfier brothers beginning in 1782. Their balloons flew when a fire was used to heat the air inside them. A duck, a sheep and a rooster were the first passengers, but in November of 1783, two men floated over Paris for 25 minutes and became the first humans to experience free flight.



Giffard dirigible

Although balloons put people in the air, they allowed little directional control; the development of airships, or dirigibles, addressed this problem. The first successful dirigible, built in 1852 by Henri Giffard, was shaped like a cigar and used hydrogen to create lift. It had a steam engine that turned a propeller and used rudders to control its direction. The LaFrance airship, built in 1884 by Charles Renard and A.C. Krebs, was the first airship that could be steered in any direction regardless of the wind.

Count Ferdinand von Zeppelin of Germany perfected the rigid dirigible at the turn of the 20th century. During World War I, Zeppelins and other airships dropped bombs over London. Both before and after the war, they enjoyed success as commercial passenger carriers. The *Hindenburg*, the largest and most famous Zeppelin, exploded on May 6, 1937, while trying to land in New Jersey. Thirty-six of the ninety-seven people on board died in the accident, and this catastrophe marked the end of the dirigible as a commercial mode of transport.



Graf Zeppelin, 1928

As Giffard, Zeppelin, and their counterparts experimented with airships, other men concentrated on winged aircraft. Sir George Cayley, often called the father of modern aerodynamics, discovered the principles of flight that govern the operation of aircraft. He applied his research to a series of gliders he designed during the first half of the 19th century. In 1853 Cayley's coachman became the first man to fly in a heavier-than-air machine, albeit primarily as a passenger—the glider had few provisions for directional control. In addition to his groundbreaking discoveries in aerodynamics, Cayley also contributed significantly to the

Cayley glider

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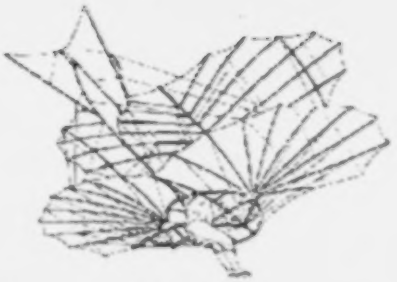
advancement of aviation by writing and publishing extensively on his research.



Lilienthal glider

Otto Lilienthal, a German, built gliders with a rigid framework that gave their fabric-covered wings a curved upper surface. This enabled them to develop lift more effectively than Cayley's all-fabric wings, which relied on air pressure to create their curvature. In 1891 he began a series of more than 2,500 successful glider flights that proved the value of this innovation. By shifting his body weight, Lilienthal was also able to achieve a degree of directional control. It was insufficient, however, to compensate for sharp gusts of wind such as the one that caused his glider to stall and sent him plummeting to his death in 1896.

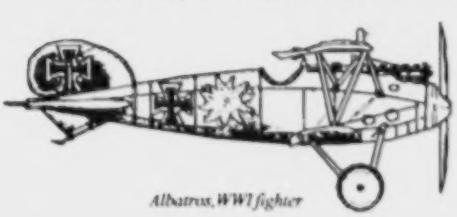
Although many experimenters around the world studied and improved on Cayley's and Lilienthal's work as the 19th century drew to a close, most were unable to overcome the two main obstacles to creating what would be called an "airplane"—a suitable source of power and an effective means of directional control.

Orville and Wilbur Wright, with their famous flights at Kitty Hawk, North Carolina, were the first to solve these problems. The Wright brothers had long been interested in flight and began experimenting with gliders in 1900. They improved the design of the wing to allow more directional control through a process known as warping. The brothers had noticed that when birds flew, they twisted the back edge of one wing upward and the back edge of the other wing downward to change their direction. The Wrights incorporated this feature into their glider design by attaching cords to the wing tips so that they could be warped. In 1902 they flew a glider with this feature successfully at Kitty Hawk, a location they had chosen for their experiments due to its favorable winds. This glider also had an elevator and a rudder to control up-and-down and side-to-side motion, respectively.

Wright Flyer, 1903

A year later, the Wrights returned to Kitty Hawk with their newest machine, the Flyer. It had the same basic design as their 1902 glider, with the addition of an engine and propellers. On December 17, 1903, the Wright brothers made the first controlled, manned, powered, heavier-than-air flights in history. The first of these flights lasted 12 seconds and traveled 120 feet. The impact of their success, however, was not felt until 1908, when the Wrights demonstrated their achievements in the U.S. and France.

The next year, 1909, was a significant year in aviation history. Louis Bleriot flew his monoplane across the English Channel from France to England, becoming the first person to fly an airplane across a body of water or from one country to another. Also in France, Elise Deroche, also known as "La Baronne de La Roche," became the first licensed woman pilot. In that same year, the first U.S. Army airplane was built by the Wright brothers. Two years later Glenn Curtiss, the father of naval aviation, flew his first successful seaplane in San Diego.



Albatross, WWI fighter

World War I spurred great advances in aviation use and technology. At the beginning of the war, airplanes were used primarily for observation. With the addition of machine guns,

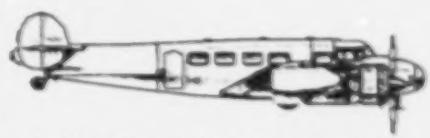
however, airplanes became effective weapons of war. Design innovations also made planes larger, faster, and capable of carrying bombs.

Curtiss Jenny, 1918 mail plane

In May 1918, the U.S. became the first country to offer regularly scheduled, year-round airmail service. The first route ran between Washington, D.C., and New York City. After the war ended in November 1918, the Post Office used many surplus Army aircraft and a smaller number of new planes to expand airmail service across the country.

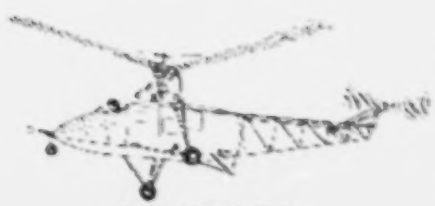
In 1927, Charles Lindbergh won a $25,000 prize, offered in 1919 by hotel owner Raymond Orteig, for accomplishing the first non-stop flight from New York to Paris. Lindbergh left New York on May 20, 1927, in his San Diego-built plane the *Spirit of St. Louis* and landed in Paris 33 hours and 30 minutes later. His solo flight made him a hero overnight and inspired aviation enthusiasts around the world.

Another famous pilot of the inter-war period, Amelia Earhart, also reached legendary status. In 1932, Earhart became the first woman pilot to cross the Atlantic alone. Most people remember her, however, because of her disappearance in 1937. Earhart and her navigator set out from Miami intending to fly around the world, but they were last heard from over the Pacific Ocean. Many theories for their disappearance exist, but all searches either then or since have failed to find any evidence of the airplane or its crew.



Lockheed Electra similar to Earhart's 1937 model

Around the time of Earhart's last flight, a man named Igor Sikorsky was working to improve another type of aircraft, the helicopter. Documents relating to the theory and design of helicopters date as far back as the fourth century, and in addition to his ornithopter, da Vinci had sketched a helicopter-like "helical air screw." In 1907, a helicopter achieved flight at about 5 feet, but it was practically uncontrollable. Sikorsky and his aircraft company perfected the single-main-rotor helicopter in the late 1930s, and the following decades brought significant improvements in performance and reliability. Helicopters are now widely used for military, emergency-rescue, and commercial purposes.

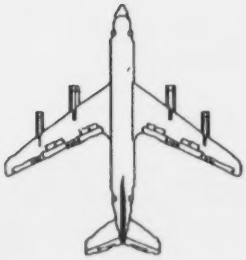


Sikorsky's VS-300, 1939

Airplanes played an important role in World War II. During this period, aviation technology again saw many advances, the most significant being the development of jet aircraft. Experiments with jet propulsion had been conducted as early as 1910, but war demands accelerated the progress being made in this area. German engineers were the first to produce an operational jet fighter, the Messerschmitt 262. Although Great Britain and the U.S. also developed jets during the war, they did not see combat; the first jet-to-jet aerial engagement did not occur until the Korean War (1950).

Messerschmitt 262

It was longer still before jets were used in commercial aviation. Great Britain's de Havilland Company developed the Comet jetliner in 1952, but withdrew them from service after two disastrous crashes. The

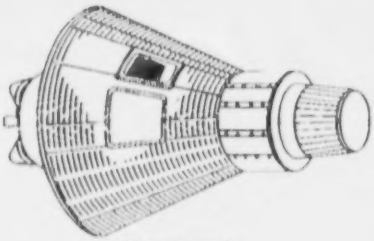


Boeing 707

problems were solved and Comets returned to transatlantic jet service in 1958, about the same time as America's Boeing 707.

Space flight had been a human dream for centuries, but in the years following World War II that dream became a reality. The Cold War between the United States and the Soviet Union motivated each to devote tremendous resources to the space race. The Soviets led with the launch of their *Sputnik* satellite on October 4, 1957, and Soviet Cosmonaut Yuri Gagarin became the first man in space on April 12, 1961.

The United States was not far behind. Projects Mercury, Gemini, and Apollo put Americans into space, into orbit, and on the moon during the 1960s. The first American in space, Alan Shepard, flew a 15-minute sub-orbital mission in a Mercury capsule on May 5, 1961. In February 1962, John Glenn was the first American to orbit the earth. In 1965, the Gemini program, with its two-man space craft, began a series of missions to perfect the skills needed to reach the moon.

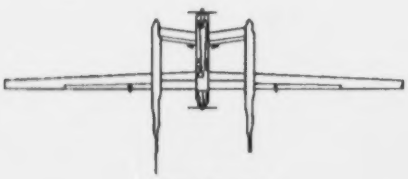


Gemini capsule

The Apollo program received a serious setback when three astronauts perished from a fire in their command module during ground testing in January 1967. In July of 1969, however, the Apollo 11 mission fulfilled President Kennedy's 1961 goal of landing on the moon before the close of the decade when Neil Armstrong, followed shortly by Buzz Aldrin, stepped onto the lunar surface.

During the 1970s, the National Aeronautics and Space Administration (NASA) began developing the Space Transportation System, or Space Shuttle. The first STS mission launched on April 12, 1981. After two days in orbit, Commander John Young and Pilot Robert Crippen safely landed the shuttle *Columbia*. Although grounded for two and a half years after the tragic loss of *Challenger* and its crew in 1986, the Space Shuttle will continue as America's primary space vehicle into the 21st century.

Since the end of the Cold War, the U.S., the former Soviet Union and other countries have been working together to advance space exploration, with the primary goal of establishing an international space station. Progress in aviation continues as well. In 1986, Dick Rutan and Jeanna Yeager became the first people to fly non-stop around the world without refueling in their sophisticated aircraft, *Voyager*. These examples demonstrate how aerospace technology continues to progress as the 21st century approaches.



Rutan Voyager

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SPACE SCRAMBLE

After learning about the parts of the space shuttle, unscramble the words below to make sentences about them. Be sure to add the correct capital letters and punctuation.

1. runway lands orbiter on a the

2. payload carries its cargo the bay the orbiter in

3. orbiter can reused the be and boosters solid rocket

4. space truck space shuttle is the as a used

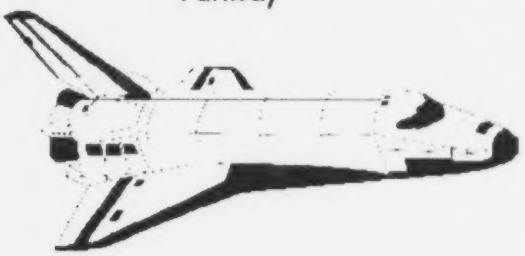
5. launched the center kennedy space is space shuttle from

6. orbit shuttle repair to satellites one missions the space of in is

SHUTTLE JUMBLE

Use the following list to help you unscramble the space words:

space shuttle	launch	scientists
orbiter	astronaut	crew
payload	reentry	rocket
satellite	altitude	airplane
booster	runway	transportation



nywaru _____ chualn _____

rlpnaeia _____ yodapal _____

lutdeati _____ ostreob _____

wrec _____ tonuatsar _____

oktecr _____ snticsetis _____

etiltasel _____ neyrter _____

rirbtoe _____ aecps htlteus _____

stanorpatniotr _____

Minds in Motion

PURPOSE Three simple activities illustrate Newton's Law's of Motion

BACKGROUND In 1687, Sir Isaac Newton published *Principia Mathematica*, a work that included the three Laws of Motion that explain the behavior of objects in motion and at rest. These laws form the foundation of the laws that govern the physics of space flight.

Newton's First Law

Objects at rest will stay at rest, and objects in motion will stay in motion in a straight line unless acted upon by an unbalanced force.

ACTIVITY: BUCKLE UP!

SUPPLIES A piece of stiff cardboard, a one-inch-thick book, masking tape, a pencil, a piece of modeling clay, a small toy car, a 12-inch piece of 1/4-inch ribbon.

PROCEDURE

1. Discuss Newton's First Law of Motion with the class, explaining how it applies to every object on Earth or in the sky. Think of examples (a ball flies through the air until it is caught, a leaf is still until the wind blows on it, etc.)

2. Lay the book flat on a table, then rest one edge of the piece of card board against it. Tape the other end of the cardboard to the table. Tape the pencil to the table about two toy-car lengths from the taped end of the cardboard.

3. Make a small snowman-shaped figure with the clay. Flatten its bottom, then set it gently on the hood of the car. Do not press the clay onto the car.

4. Release the car and its "snowman" passenger from the raised end of the cardboard and watch it roll down the cardboard and collide woth the pencil. The car will stop, but the "snowman" will sail through the air. Discuss with the students the fact that the pencil is the unbalanced force that prevents the car from staying in motion. Nothing stops the snowman, however, and it remains in motion by flying through the air.

5. Next, use the ribbon to tie the "snowman" to the car. Release the car from the raised end of the cardboard and watch what happens. Discuss these new results with the students. Why doesn't the "snowman" fly this time? Repeat the whole demonstration, with and without the ribbon after raising the cardboard higher. Have students notice that with the cardboard raised higher, the car travels faster. When it hits the pencil, the "snowman" flies farther than before if it is not tied to the car.

6. Review Newton's First Law and discuss how it applies to this experiment. This is also an ideal opportunity to remind students of the importance of wearing safety belts in a car. Point out to them that they are like the "snowman" themselves when riding in a car. If the car stops suddenly and they are not strapped in, their bodies will "stay in motion."

7. Tie the experiment in with aviation or space flight discussing with students how Newton's First Law affects airplanes and rockets.

San Diego Aerospace Museum
http://www.aerospacemuseum.org

Newton's Second Law

Force is equal to mass times acceleration.

BALLS & STRAWS

SUPPLIES Small rubber balls and drinking straws.

PROCEDURE

1. Discuss Newton's Second Law of Motion with the class, simplifying and explaining the terms force, mass, and acceleration. Explain that if you increase the force acting on an object, you increase its acceleration; if you want to decrease its acceleration, decrease the force. What happens if you increase mass? If you decrease it? Give examples students can understand. If you throw a baseball harder, it moves faster. If you throw a bowling ball with the same amount of force, does it move slower or faster?

2. Give every student a straw and a ball (if you don't have enough balls for everybody, pair the students up, but make sure everybody gets a straw). Have them blow on the ball through the straw and observe what happens. Then, starting the ball in the same place, blow harder. The ball should move faster and farther. Make sure everybody has a chance to try the experiment.

3. Then, with the students working in pairs, have them sit on opposite sides of the ball and blow on it at the same time. What happens if they use the same amount of force? What if one blows harder than the other?

4. For comparison's sake, you might want to repeat the experiment with an object with different mass, such as a crupled piece of paper. Or, better yet, have students do each step with the rubber ball, then with the other object. Why do the rubber ball and the other object react differently to the same amount of force?

5. Finish up by reinforcing the principles described in Newton's Second Motion. Tie in with aviation and space flight by discussing how heavier airplanes must travel faster to achieve lift than lighter gliders or by comparing the amount of force required to lift the different rockets used in the American space programs (Atlas, Redstone, Titan, Saturn, etc.).

Newton's Third Law

For every action there is an equal and opposite reaction.

WILD BALLOONS

SUPPLIES - One balloon per student

PROCEDURE

1. Discuss Newton's Third Law of Motion with the class. Brainstorm some examples of "equal and opposite reactions."

2. Give every student a balloon. Have them inflate the balloons, pinching the open end shut with their fingers. Have everyone let go of their balloons at the same time and then discuss what happened. Explain that the air inside the balloon wants to escape. When it finds a hole to leave through, it rushes out. The force of it actually pushes the balloon in the opposite direction.

3. Wrap up by reinforcing Newton's Third Law. Tie in with aviation and space flight by discussing how thrust works in propeller airplanes, jets, and rockets.

"WHERE WERE YOU WHEN . . . ?"

PURPOSE Students develop an appreciation for recent history.

TASK Students conduct interviews to discover what adults recall about the 1969 lunar landing.

SUPPLIES Reference materials, notebooks, paper, pencils, art supplies.

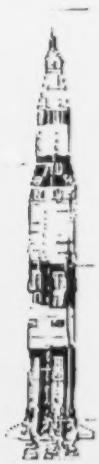
PROCEDURE

1. Provide students with information about the lunar landing on July 20, 1969, and the astronauts' moonwalk. If possible, show them the television broadcast of that event.
2. Have students interview five people who are old enough to remember the event. Let the class brainstorm to create a list of interview questions. Get the ball rolling by suggesting a few questions: "How old were you in 1969?," "Where did you live?," "What did you think was important about the moon landing in 1969?," "What do you think is its significance today?," etc. Make sure students record their subjects' answers either in a notebook or on audio tape.
3. Have students write a brief report on their subjects' recollections, complete with illustrations.
4. Discuss the reports as a class. If the opportunity arises, discuss the difference between memory and history by comparing memories of the lunar landing to what actually happened.

OPTIONAL

Compile the reports into a book. Have students design its cover. Share the book with another class, or have students present what they have learned to another class.

Repeat the oral history project using another significant event in recent history, such as the explosion of the space shuttle *Challenger* in 1986, John F. Kennedy's assassination in 1963 or the fall of the Berlin Wall in 1989.



Saturn V with Apollo spacecraft

SPACE MATH

Solve the problems below. You will need to convert numbers into the metric system to come up with the correct answers.

1. The shuttle orbiter can carry up to 65,000 pounds [kilograms] of payload into space.

2. Satellites in geostationary orbits are placed 22,300 miles [kilometers] above the earth.

3. The first successful probe of another planet occured on December 14, 1962, when Mercury 2 passed within 22,000 miles [kilometers] of Venus. The 447-pound [kilogram] probe recorded Venus' surface temperature at 700 degrees Fahrenheit [Celsius] and sent back valuable data on previously unexplored space.

4. Astronauts who are mission specialists must be between 60 and 76 inches in height. Mary is a physicist who is 140 centimeters tall. Can she become a mission specialist?

5. The shuttle's external tank holds up to 440,000 gallons [liters] of propellant.

6. The Lunar Rover used on the last three Apollo missions had a maximum speed of 10 miles [kilometers] per hour.

7. Alan Shepard's suborbital mission lasted 15 minutes; his Freedom 7 space craft flew 116 miles [kilometers] high into space.

8. A Saturn V rocket at liftoff weighs 6,384,000 pounds [kilograms].

METRIC CONVERSION

1 POUND = .45 KILOGRAMS
1 KILOGRAM = 2.20 POUNDS

1 MILE = 1.61 KILOMETERS
1 KILOMETER = .62 MILE

1 INCH = 2.54 CENTIMETERS
1 CENTIMETER = .39 INCH

1 GALLON = 3.79 LITERS
1 KILOLITER = 264.18 GALLONS

To convert Fahrenheit temperatures into Celsius, subtract 32 degrees and divide by 1.80.

MESSAGE FROM THE MOON

On July 20, 1969, at 10:56 p.m., astronaut Neil Armstrong put his left foot on the moon. Decode the following message to find out what he said at that historic moment.

10 = C
11 = X
12 = T
14 = E
16 = A
17 = B
18 = W
21 = S
24 = N
25 = G
29 = U
30 = L
32 = V
33 = K
35 = Z
36 = O
40 = M
42 = R
48 = H
49 = P
50 = F
54 = D
55 = Q
81 = I
82 = J
90 = Y

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